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Chemistry 102b
General Chemistry
Exam #2

Name (Printed) _____

I pledge, on my honor, that I have neither given nor received inappropriate aid on this examination

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Signature

<u>Circle</u> the section in which you are officially registered.

Section 1 - Rosenthal Section 2 - Ekman Section 3 - Stone

- Constants, equations, a periodic table, and reduction potentials are on a separate handout.
- Do not begin until instructed to do so.
- When working numerical problems, present your work in a neat and logical fashion, with units, to obtain the maximum credit.

Section I. True/False Circle the correct answer. 2 pts each, 10 pts total

1. The loss of electrons is oxidation. TRUE FALSE

2. Faraday's Law states that the quantity of a substance produced or consumed at an electrode during an electrochemical reaction is proportional to the concentration of that substance in the solution in contact with the electrode.
   TRUE FALSE

3. The purpose of a salt bridge is to prevent mixing of the solutions present in two half-cells, but allow ions to pass between them.
   TRUE FALSE

4. The standard cell potential for a certain electrochemical cell is $E° = 0.050$ V. Useful work can be extracted from this cell.
   TRUE FALSE

5. It is impossible to measure the voltage of an isolated half-cell.
   TRUE FALSE

Section II. Circle the correct answer. 2 pts each, 10 pts total

6. Which of the following has the greater carbon content?
   STEEL PIG IRON

7. Which of the following metals is most likely to be refined by electrorefining?
   GOLD ALUMINUM

8. Which of the following metals will serve as the better sacrificial anode in protecting steel from corrosion?
   ZINC NICKEL

9. Based on periodic trends, which of the following **elements** would be expected to be the stronger oxidizing agent?
   SULFUR CALCIUM

10. The chemical species consumed at the anode of a dry cell battery is which of the following?
    ZINC MnO_2

Section III. Short Answers 8 points total (Points as indicated)

A voltaic cell is constructed from two beakers. In one beaker is a silver strip placed in a solution of silver nitrate, $AgNO_3$. The other beaker has a nickel strip placed in a solution of nickel chloride, $NiCl_2$. A salt bridge connects the two half-cells.

11. Which metal is the cathode? (1 pt)

12. Write the reduction half-reaction. (1 pt)

13. Write the oxidation half-equation. (1 pt)

14. Write the overall (net) balanced cell equation. (1 pt)

15. Which electrode is negative? (1 pts)

16. Write the cell notation for this electrochemical cell. (2 pts)

17. Which metal strip gains mass? (1 pts)

Section IV. Multiple choice Circle *only* the (one) correct answer. 4 pts each, 40 pts total

18. In class we demonstrated the electrochemistry Christmas tree (or "silver tree"). This was a demonstration of:
    A. An electrolytic cell in which silver was electroplated on a tin sphere to make a Christmas tree ornament.
    B. A spontaneous electrochemical reaction in which silver metal "branches" spontaneously formed on a copper wire "Christmas tree".
    C. An electrolytic cell in which green "branches" were electroplated onto a silver electrode to form the shape of a Christmas tree in a petri dish.
    D. Several galvanic cells connected in series to form a battery and produce enough current to light up a small silver ceramic Christmas tree.

19. In class we demonstrated the Daniel Cell: $Zn(s)|Zn^{+2}(aq)||Cu^{+2}(aq)|Cu(s)$. This was a demonstration of
    A. a fuel cell
    B. an electrolytic cell
    C. an electrolysis cell
    D. a galvanic cell

20. Which of the following is most likely to be an oxidizing agent?
    A. permanganate ion (MnO_4^{--})
    B. fluoride ion
    C. sodium metal
    D. zinc chloride
    E. lithium ion

21. A spontaneous REDOX reaction has
    A. $\Delta G° = 0$, $\Delta E° = 0$, and $K >> 1$
    B. $\Delta G° < 0$, $\Delta E° > 0$, and $K > 1$
    C. $\Delta G° > 0$, $\Delta E° < 0$, and $K < 1$
    D. $\Delta G° > 0$, $\Delta E° < 0$, and $K > 1$
    E. $\Delta G° < 0$, $\Delta E° = 0$, and $K >> 1$

22. The respective standard reduction potentials for Fe^{2+} and Ag^{+} are –0.41 V and +0.80 V. The oxidizing agent in this cell will be:
    A. Fe
    B. Fe^{2+}
    C. Ag^{+}
    D. Ag

23. Which substance serves as the reducing agent in the following reaction?
    $Fe_2S_3 + 12\ HNO_3 \rightarrow 2\ Fe(NO_3)_3 + 3S + 6\ NO_2 + 6H_2O$
    A. HNO_3
    B. S
    C. NO_2
    D. Fe_2S_3

24. Which of the following expressions can be used to describe a "dead" (fully discharged) battery?
    A. $E < 0$
    B. $E > 0$
    C. $E = 0$
    D. $K = 1$
    E. none of the above

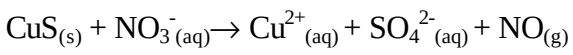
25. The lead-acid battery is a secondary battery because
    A. it is rechargeable because the products of the reaction remain in contact with the electrodes.
    B. it produces a voltage which is higher than primary batteries.
    C. the electrolyte is an aqueous solution.
    D. it is considered a dry cell battery.
    E. it is not very portable.

26. Consider an **electrolytic** cell consisting of a half-cell in which an iron electrode is in contact with a solution of Fe^{2+} and a copper electrode is immersed in a solution of Cu^{2+}. Which chemical species will be produced at the cathode?
    A. Cu
    B. Cu^{2+}
    C. Fe
    D. Fe^{2+}

Section V SHOW YOUR WORK TO RECEIVE FULL CREDIT 5 pts

Circle the answer to be graded.

27. Complete and balance the following equation which occurs in acidic solution.



$$CuS_{(s)} + NO_3^-{}_{(aq)} \rightarrow Cu^{2+}{}_{(aq)} + SO_4^{2-}{}_{(aq)} + NO_{(g)}$$

Section VI SHOW YOUR WORK TO RECEIVE FULL CREDIT 9 pts

28. A voltaic cell utilizes the following reaction.
$2\ Fe^{3+}_{(aq)} + H_{2(g)} \rightarrow 2\ Fe^{2+}_{(aq)} + 2\ H^{+}_{(aq)}$

B. Calculate the voltage of this cell under standard conditions. (2 pts)

C. Calculate the voltage of this cell operating at 298.15 K when $[Fe^{3+}] = 0.600$ M, $P_{H_2} = 0.200$ atm, $[Fe^{2+}] = 0.020$ M, and $[H^{+}]$ in both compartments is 1.00×10^{-4} M. (6 pts)

Section VII SHOW YOUR WORK TO RECEIVE FULL CREDIT 9 pts

29. A galvanic cell is set up utilizing the following reaction.
$Mg\,(s) + Cd^{2+}\,(aq) \rightarrow Mg^{2+}\,(aq) + Cd\,(s)$

The magnesium electrode is immersed in a solution of 0.55 M $MgSO_4$. The cadmium electrode is immersed in a Cd^{2+} solution of unknown concentration.

a. Calculate the standard cell potential for this cell. (2 pts)

b. The actual cell potential at 298.15 K is measured to be 1.857 V. Calculate the molar concentration of cadmium in the unknown solution. (6 pts)

Section VIII SHOW YOUR WORK TO RECEIVE FULL CREDIT 9 pts

30. A galvanic cell operating at 25.0°C consists of an aluminum anode immersed in an $AlCl_3$ solution and a graphite cathode which is in contact with F_2 gas at a constant pressure of 1.20 atm pressure and a solution of KF.

a. Write a balanced net equation for this cell reaction. **Circle** the answer you want graded. (2 pts)

b. A current of 0.650 A is allowed to pass between the electrodes for 45.0 minutes. Calculate the change in mass of the aluminum electrode during the reaction. (3 pts)

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b. Calculate the volume of fluorine gas consumed during the reaction described in part b, above. (4 pts)

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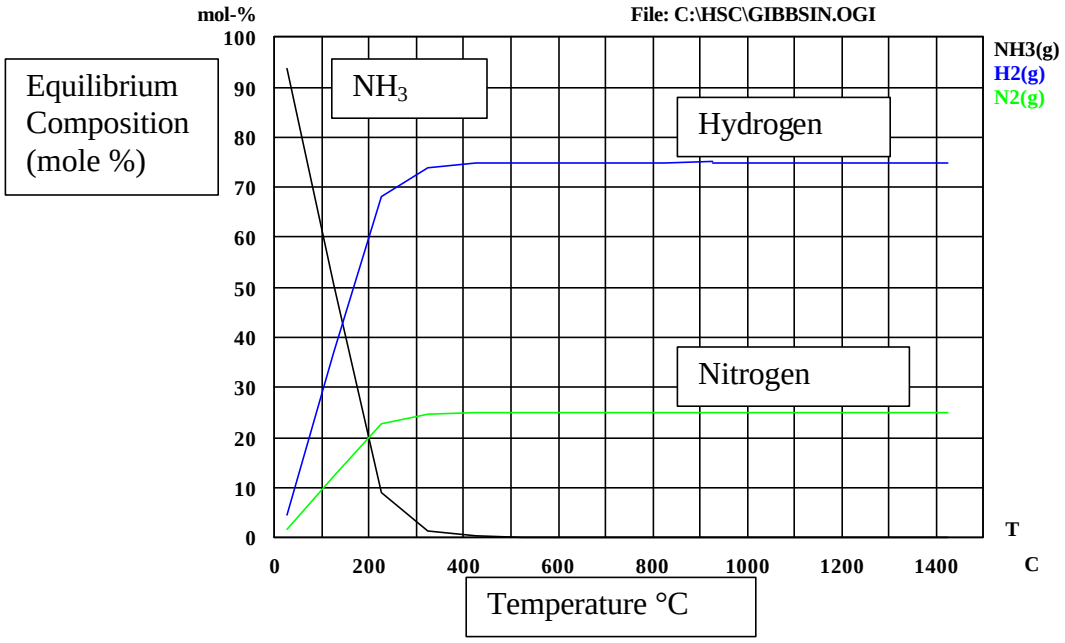
Section IX EXTRA CREDIT-10pts-ALL OR NOTHING-NO PARTIAL CREDIT

SHOW YOUR WORK TO RECEIVE FULL CREDIT

DO NOT EVEN READ THIS QUESTION UNLESS YOU HAVE FINISHED AND CHECKED YOUR EXAM-Show all of your work to get extra credit

Some planets, like Jupiter, have ammonia in the atmosphere. The graph below was constructed from thermodynamic data and gives the equilibrium amounts (in terms of mole %) of ammonia, hydrogen, and nitrogen gas when ammonia decomposes at the different temperatures indicated on the x-axis. Notice that at lower temperatures ammonia does not significanlty decompose. The average temperature on Jupiter is –130°C, so exisitng ammonia remains in the atmosphere. For 10pts extra credit, using the data displayed in the graph calculate $G°$ for the decomposition of ammonia at 200°C (assume the decomposition occurs at 1 atm pressure). Recall R=0.08206 L-atm/mol K. To read more about Jupiter, visit http://galileo.jpl.nasa.gov/jupiter.



Print your name at the bottom of this page in the space provided. If you think there was a typographical error or a problem which did not have enough information to be solved, please explain in the space below.

Remember to sign the Honor Code on the cover page if you have upheld the honor code.

Section	Points Lost
I	– _____ (out of 10)
II	– _____ (out of 10)
III	– _____ (out of 8)
IV	– _____ (out of 40)
V	– _____ (out of 5)
VI	– _____ (out of 9)
VII	– _____ (out of 9)
VIII	– _____ (out of 9)
IX	+ _____ (10 extra)
Total	_____ / 100

Print your name, last name first

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Equations

$I=Q/t$

$W_{elec}= -Q \quad E$

$G°=-nF \quad E°$

$G= \quad G° + RT\ln Q$

$E= \quad E° - (RT/nF)\ln Q$

at T=298.15 K, log base 10, $E= \quad E° - (0.0592V/n) \log Q$

$\ln K= (nF/RT) \quad E°$

at 298.15K: $\log K=(n/0.0592V) \quad E°$

Constants

Gas Constant	8.3145 J / mol K
	0.08206 L atm / mol K
Faraday Constant	96485 C / mol e^-

Reduction Half-Reaction	E° (V)
$F_2\,(g) + 2\,e^- \rightarrow 2\,F^-$	2.87
$MnO_4^- + 4\,H^+ + 3\,e^- \rightarrow Mn^{2+} + 2\,H_2O$	1.491
$MnO_2\,(s) + 4\,H^+ + 2\,e^- \rightarrow Mn^{2+} + 2\,H_2O$	1.208
$Ag^+ + e^- \rightarrow Ag\,(s)$	0.7996
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.770
$Cu^{2+} + 2\,e^- \rightarrow Cu\,(s)$	0.3402
$2\,H^+ + 2\,e^- \rightarrow H_2\,(g)$	0.000
$Ni^{2+} + 2\,e^- \rightarrow Ni\,(s)$	-0.23
$Cd^{2+} + 2\,e^- \rightarrow Cd\,(s)$	-0.4026
$Fe^{2+} + 2\,e^- \rightarrow Fe\,(s)$	-0.409
$Zn^{2+} + 2\,e^- \rightarrow Zn\,(s)$	-0.7628
$Cr^{3+} + 3\,e^- \rightarrow Cr\,(s)$	-0.8277
$Al^{3+} + 2\,e^- \rightarrow Al\,(s)$	-1.706
$Mg^{2+} + 2\,e^- \rightarrow Mg\,(s)$	-2.375
$Na^+ + e^- \rightarrow Na\,(s)$	- 2.7109
$Li^+ + e^- \rightarrow Li\,(s)$	- 3.045